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# Rapid-photometry of Wolf-Rayet Stars: a search for strange-mode pulsations

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## Abstract

Theoretical work suggests that strange-mode pulsations (SMPs) are present in the envelope of hot and luminous stars with a large luminosity-to-mass ratio, where the thermal timescale is short compared to the dynamical timescale, and where radiation pressure dominates (Glatzel et al. 1993). The most violent SMPs are expected in classical Wolf-Rayet (WR) stars, i.e the bare, compact helium-burning cores of evolved massive stars (Glatzel et al. 1999), where SMPs manifest themselves in cyclic photometric variability with periods ranging from minutes to hours. However, these variabilities are expected to be epoch-dependent. Here we report on our attempts to detect SMPs in several WR stars using rapid, high-precision photometry.

Individual Objects: BAT99 47, WR 2

## Rapid Photometry in the Optical

Conventional optical cameras feature CCDs that normally have read-out times ranging from a few tens of seconds to minutes to ensure minimum read-out noise. This severely limits the possible duty cycle for rapid-photometry applications. Windowing-down of the detector is a possible solution, but the cost is a highly limited field of view (FOV) which makes it extremely difficult to frame suitable comparison stars for differential photometry. The problem becomes very acute if very bright (and thus very rare) stars are targeted to ensure high S/N within very short exposure times. During semesters 2003B and 2004A, the Acquisition Camera (AcqCam) was attached to Gemini South's Cassegrain focus. With its 1k x 1k, thermo-electrically cooled CDD, AcqCam offers the capability for rapid (6.3 sec) read-out of a full 2' x 2' frame (0.12" per pixel). To provide both a sufficiently large number of comparison stars in the relatively small field, we targeted BAT99-47 (WN3b), a hot, hydrogen-free WR star in the LMC. Over a period of 8 hours, we obtained a short (2 sec exposure time) broadband-V image every 8.3 seconds. Despite the fact that BAT99-47 turned out to be considerably fainter than the V = 14.1 mag listed in the literature (cf. BAT99), and crowded with a (fainter) star (cf. Figure 1a), a photometric precision of $\sigma \sim 3$ mmag for the WR star was achieved for each data point using DAOPHOT, a package for stellar photometry designed to deal with crowded fields. Preliminary results (cf. Figure 1b) indicate that while no periodic, short-time scale variability seems to be present at a level of 3 mmag (except for some small uncorrected local atmospheric variations), there is a slow variation in the flux within 8 hours. The analysis of

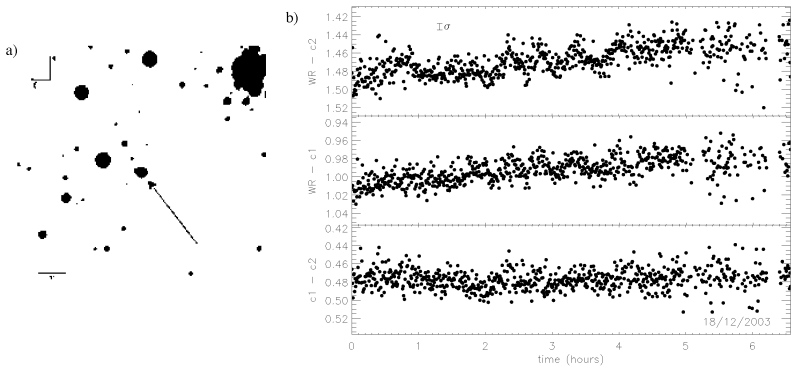


Figure 1: a) A 40"x40"-wide zoom of the field around BAT99 47 (pointed with the arrow) observed with AcqCam. A faint star can be seen at the east, very close to BAT99 47. b) Light-curve of BAT99 47 relative to two different comparison stars, compared to the difference between the two comparison stars.

this phenomenon is ongoing, but it could be that the timescale of the variability of BAT99-47 is longer than the duration of our run.

## The Near-Infrared Cameras

If fast-readout, low-noise optical CCDs are not (yet) widely available, near-infrared (NIR) detectors have very short read-out times by design, and wide-field NIR cameras (e.g. WIRCAM, WFCAM,...) are readily available at all major observatories. Due to interstellar extinction, many Galactic OB and WR stars are optically faint, but very bright in the NIR, thereby limiting the sky-brightness issues that normally relate to NIR imaging. Moreover, the fact that massive stars reside in clusters makes for an excellent availablity of many equally bright comparison stars. Thus, rapid, high-precision differential photometry should be relatively easy with conventional and existing instruments. As a first test, we have used SIMON (Spectromètre Infrarouge de Montréal), a NIR spectro-imager that provides a 8' x 8' FOV at the Observatoire du mont Mégantic (OMM) (Québec). We have observed WR 2 (WN2), the hottest Galactic WR star known, and obtained a full 2k x 2k frame in J band every 5.4 sec during 4 partial nights of 3 hours each. Differential photometry yielded a precision of $\sigma$ ∼10 mmag for the preliminary light-curve which covers 3.2 hours (cf. Figure 2a). WR 2 shows a marginal, sinusoidal curve with an amplitude of ∼20 mmag (2 $\sigma$) and a possible frequency of ∼0.55 cycle per hour (P = 1.8 hours) that is not present in the comparison stars (see the periodogram in Figure 2b). The same behaviour is observed in data that were obtained 3 days later. A more detailed analysis is in progress.

## Conclusions

To search for SMPs (or any other type of short-term variability) in OB and WR stars, rapid, high-precision, differential photometry is required. Moderately wide-field, full-frame imaging dramatically increases the availability of suitable comparison stars. While optical CCD cameras are known to deliver very high photometric accuracy (a few mmags), initial tests indicate that conventional NIR cameras can be used with excellent results; these tests indicate that

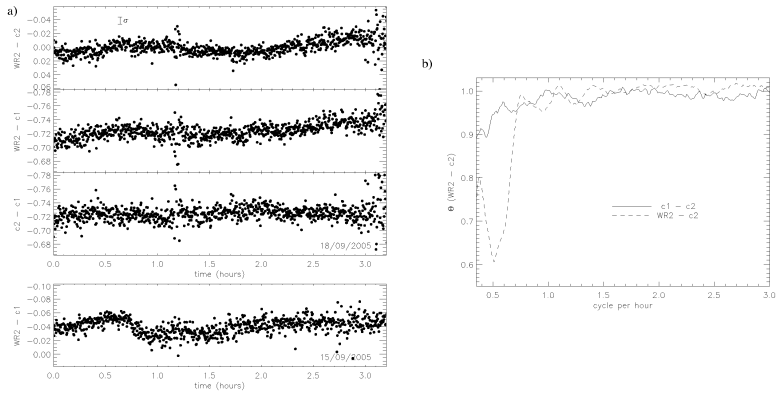


Figure 2: a) WR 2 light-curve versus two comparison stars and between two comparison stars on 18/09/2005 and WR2-c1 on 15/09/2005. b) Periodogram calculated using PDM on the two light-curves c1 - c2 (solid line) and WR 2 - c2 (dashed line) observed on 18/09/2005.

even under suboptimal observing conditions, a 10 mmag photometric precision can easily be reached. Better observational conditions and more sophisticated data reduction and analysis techniques might yield even higher accuracy. Thus, rapid NIR photometry using existing designs on 2 to 4m-class telescopes is a highly viable approach, in particular if the variability is expected to reach amplitudes of few tens of mmags. Preliminary results of our ongoing rapid-photometry campaign indicate that in none of the two observed, hot WN stars, BAT99-47 in the LMC and WR 2 in the Milky Way, is a short-period (few minutes) cyclic variability present. However, a period of 1.8 hours may have been found in the WR 2 light-curve.

## References

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